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Period 3

Determining the K_c Constant of the Reaction Between Iron(III) and Thiocyanate

Raw Data:

The Change in Absorbance when the Amount of KSCN and H₂O Change

Test Tube Number	Fe(NO ₃) ₃ (mL)	KSCN (mL)	H ₂ O(mL)	Absorbance
1	5 ± 0.05	2 ± 0.05	3 ± 0.05	0.477 ± 0.001
2	5 ± 0.05	3 ± 0.05	2 ± 0.05	0.734 ± 0.001
3	5 ± 0.05	4 ± 0.05	1 ± 0.05	1.920 ± 0.001
4	5 ± 0.05	5 ± 0.05	0	1.964 ± 0.001
5	18 ± 0.05	2 ± 0.05	0	1.455 ± 0.001

Temperature of one of the first four solutions: 20.4°C

Processed Data:

Data and Calculations Table

1. K _c expression	K _c =[FeSCN ²⁺]/[Fe ³⁺ _{aq}][SCN ⁻ _{aq}]			
	Test Tube 1	Test Tube 2	Test Tube 3	Test Tube 4
2. [Fe ³⁺] _i	1 × 10 ⁻³ ± 2.5 × 10 ⁻⁵ M	1 × 10 ⁻³ ± 2.5 × 10 ⁻⁵ M	1 × 10 ⁻³ ± 2.5 × 10 ⁻⁵ M	1 × 10 ⁻³ ± 2.5 × 10 ⁻⁵ M
3. [SCN ⁻] _i	4 × 10 ⁻⁴ ± 2.5 × 10 ⁻⁵ M	6 × 10 ⁻⁴ ± 2.5 × 10 ⁻⁵ M	8 × 10 ⁻⁴ ± 2.5 × 10 ⁻⁵ M	1 × 10 ⁻³ ± 2.5 × 10 ⁻⁵ M
3.5 [FeSCN ²⁺] _{eq}	6.56 × 10 ⁻⁵ M ± 2.5 × 10 ⁻⁵ M	1.01 × 10 ⁻⁴ M ± 2.5 × 10 ⁻⁵ M	2.64 × 10 ⁻⁴ M ± 2.5 × 10 ⁻⁵ M	2.700 × 10 ⁻⁴ M ± 2.5 × 10 ⁻⁵ M
4. [Fe ³⁺] _{eq}	9.344 × 10 ⁻⁴ M ± 2.5 × 10 ⁻⁵ M	8.99 × 10 ⁻⁴ M ± 2.5 × 10 ⁻⁵ M	7.36 × 10 ⁻⁴ M ± 2.5 × 10 ⁻⁵ M	7.3 × 10 ⁻⁴ M ± 2.5 × 10 ⁻⁵ M

5. $[SCN^-]_{eq}$	$3.344 \times 10^{-4} M$ $\pm 2.5 \times 10^{-5} M$	$4.99 \times 10^{-4} M$ $\pm 2.5 \times 10^{-5} M$	$5.36 \times 10^{-4} M \pm 2.5 \times 10^{-5} M$	$7.3 \times 10^{-4} M \pm 2.5 \times 10^{-5} M$
6. K_c value	$209.9 \pm 2.5 \times 10^{-5} M$	$225.1 \pm 2.5 \times 10^{-5} M$	$669.2 \pm 2.5 \times 10^{-5} M$	$506.7 \pm 2.5 \times 10^{-5} M$
7. Average of K_c values: $402.725 \pm 2.5 \times 10^{-5} M$ at $20.4^\circ C$				

1.

$$K_c = [FeSCN^{2+}]_{aq}/[Fe^{3+}]_{aq}[SCN^-]_{aq}$$

2.

$$\text{Test tube 1, 2, 3, 4: } [Fe^{3+}]_i = (5 \pm 0.05/10 \pm 0.15) \times (0.002 M) = 1 \times 10^{-3} \pm 2.5 \times 10^{-5} M$$

3.

$$\text{Test tube 1: } [SCN^-]_i = (2 \pm 0.05/10 \pm 0.15) \times (0.002 M) = 4 \times 10^{-4} \pm 2.5 \times 10^{-5} M$$

$$\text{Test tube 2: } [SCN^-]_i = (3 \pm 0.05/10 \pm 0.15) \times (0.002 M) = 6 \times 10^{-4} \pm 2.5 \times 10^{-5} M$$

$$\text{Test tube 3: } [SCN^-]_i = (4 \pm 0.05/10 \pm 0.15) \times (0.002 M) = 8 \times 10^{-4} \pm 2.5 \times 10^{-5} M$$

$$\text{Test tube 4: } [SCN^-]_i = (5 \pm 0.05/10 \pm 0.15) \times (0.002 M) = 1 \times 10^{-3} \pm 2.5 \times 10^{-5} M$$

3.5

$$\text{Test tube 1: } [FeSCN^{2+}]_{eq} = (0.477 \pm 0.001)/(1.455 \pm 0.001) \times (0.0002 M) = 6.56 \times 10^{-5} M \pm 2.5 \times 10^{-5} M$$

$$\text{Test tube 2: } [FeSCN^{2+}]_{eq} = (0.734 \pm 0.001)/(1.455 \pm 0.001) \times (0.0002 M) = 1.01 \times 10^{-4} M \pm 2.5 \times 10^{-5} M$$

$$\text{Test tube 3: } [FeSCN^{2+}]_{eq} = (1.920 \pm 0.001)/(1.455 \pm 0.001) \times (0.0002 M) = 2.64 \times 10^{-4} M \pm 2.5 \times 10^{-5} M$$

$$\text{Test tube 4: } [FeSCN^{2+}]_{eq} = (1.964 \pm 0.001)/(1.455 \pm 0.001) \times (0.0002 M) = 2.70 \times 10^{-4} M \pm 2.5 \times 10^{-5} M$$

4.

$$\text{Test tube 1: } [Fe^{3+}]_{eq} = (1 \times 10^{-3} \pm 2.5 \times 10^{-5} M) - (6.56 \times 10^{-5} M \pm 2.5 \times 10^{-5} M) = 9.344 \times 10^{-4} M \pm 2.5 \times 10^{-5} M$$

$$\text{Test tube 2: } [Fe^{3+}]_{eq} = (1 \times 10^{-3} \pm 2.5 \times 10^{-5} M) - (1.01 \times 10^{-4} M \pm 2.5 \times 10^{-5} M) = 8.99 \times 10^{-4} M \pm 2.5 \times 10^{-5} M$$

$$\text{Test tube 3: } [Fe^{3+}]_{eq} = (1 \times 10^{-3} \pm 2.5 \times 10^{-5} M) - (2.64 \times 10^{-4} M \pm 2.5 \times 10^{-5} M) = 7.36 \times 10^{-4} M \pm 2.5 \times 10^{-5} M$$

$$\text{Test tube 4: } [Fe^{3+}]_{eq} = (1 \times 10^{-3} \pm 2.5 \times 10^{-5} M) - (2.70 \times 10^{-4} M \pm 2.5 \times 10^{-5} M) = 7.3 \times 10^{-4} M \pm 2.5 \times 10^{-5} M$$

5.

$$\text{Test tube 1: } [\text{SCN}^-]_{\text{eq}} = (4 \times 10^{-4} \pm 2.5 \times 10^{-5} \text{ M}) - (6.56 \times 10^{-5} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) = 3.344 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}$$

$$\text{Test tube 2: } [\text{SCN}^-]_{\text{eq}} = (6 \times 10^{-4} \pm 2.5 \times 10^{-5} \text{ M}) - (1.01 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) = 4.99 \times 10^{-4} \pm 2.5 \times 10^{-5} \text{ M}$$

$$\text{Test tube 3: } [\text{SCN}^-]_{\text{eq}} = (8 \times 10^{-4} \pm 2.5 \times 10^{-5} \text{ M}) - (2.64 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) = 5.36 \times 10^{-4} \pm 2.5 \times 10^{-5} \text{ M}$$

$$\text{Test tube 4: } [\text{SCN}^-]_{\text{eq}} = (1 \times 10^{-3} \pm 2.5 \times 10^{-5} \text{ M}) - (2.70 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) = 7.3 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}$$

6.

$$K_c = [\text{FeSCN}^{2+}]_{\text{eq}} / [\text{Fe}^{3+}]_{\text{eq}} [\text{SCN}^-]_{\text{eq}}$$

$$\text{Test tube 1: } (6.56 \times 10^{-5} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) / (9.344 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) (3.344 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) = 209.9 \pm 2.5 \times 10^{-5} \text{ M}$$

$$\text{Test tube 2: } (1.01 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) / (8.99 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) (4.99 \times 10^{-4} \pm 2.5 \times 10^{-5} \text{ M}) = 225.1 \pm 2.5 \times 10^{-5} \text{ M}$$

$$\text{Test tube 3: } (2.64 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) / (7.36 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) (5.36 \times 10^{-4} \pm 2.5 \times 10^{-5} \text{ M}) = 669.2 \pm 2.5 \times 10^{-5} \text{ M}$$

$$\text{Test tube 4: } (2.70 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) / (7.3 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) (7.3 \times 10^{-4} \text{ M} \pm 2.5 \times 10^{-5} \text{ M}) = 506.7 \pm 2.5 \times 10^{-5} \text{ M}$$

7.

$$\text{Average } K_c \text{ value: } (209.9 \pm 2.5 \times 10^{-5} \text{ M}) + (225.1 \pm 2.5 \times 10^{-5} \text{ M}) + (669.2 \pm 2.5 \times 10^{-5} \text{ M}) + (506.7 \pm 2.5 \times 10^{-5} \text{ M}) / 4 = 402.725 \pm 2.5 \times 10^{-5} \text{ M}$$

Paragraph explaining meaning of K_c value:

K_c is a constant of equilibrium that is expressed in terms of molar concentration. If K_c is greater than 1, it means that there are more products formed. If K_c is less than 1, that means that there are more reactants than products. If K_c is equal to 1, the amount of products is equal to the amount of reactants. In this experiment, to increase the K_c value even more, we should add more KSCN. This increases the amount of products in the reaction. To decrease the K_c value, we would add AgNO_3 because that would react with SCN^- and create AgSCN rather than allowing the SCN^- to react with Fe^{3+} .

Link to document:

<https://docs.google.com/a/hanovernorwichschools.org/document/d/17EvZnmfvi1gcKyOowakzHb1WL4lH43LgHefYI2ZsH8/edit?usp=sharing>

Spreadsheet:

<https://docs.google.com/a/hanovernorwichschools.org/spreadsheets/d/1Bpo2OJGvbVfIPMd58RHI-kPckr5Xnbc7ZoZo9rvPEjI/edit?usp=sharing>